Superfinishing Processes

Honing

Honing is a finishing process that uses fine abrasive stones to remove very small amounts of metal. Cutting speed is much lower than that of grinding. The process is used to size and finish bored holes, remove common errors left by boring (taper, waviness, and tool marks) or remove the tool marks left by grinding. The amount of metal removed is typically about 0.01 mm or less. Although honing occasionally is done by hand, as in finishing the face of a cutting tool, it is usually done with special equipment. Most honing is done on internal cylindrical surfaces, such as automobile cylinder walls. The honing stones usually are held in a honing head, with the stones being held against the work with controlled light pressure. The honing head is not guided externally but, instead, floats in the hole, being guided by the work surface (Figure 1).

The stones are given a complex motion so as to prevent a single grit from repeating its path over the work surface. Rotation is combined with an oscillatory axial motion. For external and flat surfaces, varying oscillatory motions are used. The length of the motions should be such that the stones extend beyond the work surface at the end of each stroke. A cutting fluid is used in virtually all honing operations. The critical process parameters are the rotational speed (V_r), oscillation speed (V_o), the length and position of stroke, and the honing stick pressure. (V_c) and the inclination angle are both products of (V_c) and (V_r).

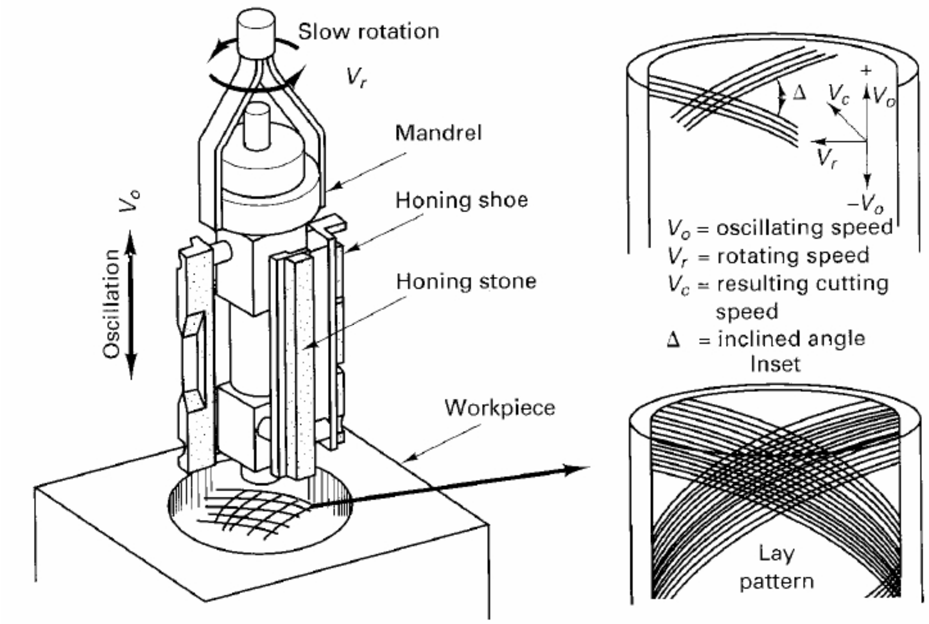

Fig. (1) Schematic of honing head showing the manner in which the stones are held. The rotary and oscillatory motions combine to produce a crosshatched lay pattern.

Honing Stones

Virtually all honing is done with stones made by bonding together various fine artificial abrasives. Honing stones differ from grinding wheels in that additional materials, such as sulfur, resin, or wax, are often added to the bonding agent to modify the cutting action. The abrasive grains range in size from 80 to 600 grit. The stones are equally spaced about the periphery of the tool.

Single and multiple spindle honing machines are available in both horizontal and vertical types. Some are equipped with special, sensitive measuring devices that collapse the honing head when the desired size has been reached.

For honing single, small, internal cylindrical surfaces, a procedure is often used wherein the workpiece is manually held and reciprocated over a rotating hone. If the volume of work is sufficient, honing is a fairly inexpensive process.

Superfinishing

Superfinishing is a variation of honing that is typically used on flat surfaces. The process is characterized with:

1. Very light, controlled pressure,
2. Rapid (over 400 cycles per minute), short strokes less than 6 mm,
3. Stroke paths controlled so that a single grit never traverses the same path twice,
4. Plentiful amount of low viscosity lubricant / coolant flooded over the work surface.

This procedure, as illustrated in Figure 2, results in surfaces of very uniform, repeatable smoothness.

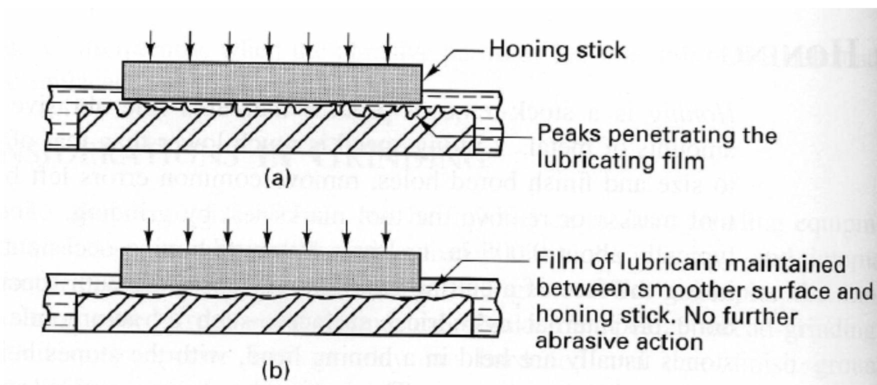

Fig. (2) Manner in which a film of lubricant is established between the work and the abrasive stone in superfinishing as the work becomes smoother.

Superfinishing is based on the phenomenon that a lubricant of a given viscosity will establish and maintain a separating, lubricating film between two mating surfaces if their roughness does not exceed a certain value and if a certain critical pressure, holding them

apart, is not exceeded. Consequently, as the minute peaks on a surface are cut away by the honing stone, applied with a controlled pressure, a certain degree of smoothness is achieved. The lubricant establishes a continuous film between the stone and the workpiece and separates them so that no further cutting action occurs. Thus, with a given pressure, lubricant, and honing stone, each workpiece is honed to the same degree of smoothness.

Superfinishing is applied to both cylindrical and plane surfaces. The amount of metal removed usually is less than 0.05 mm, most of it being the peaks of the surface roughness. Plentiful amounts of lubricant/coolant maintain the work at a uniform temperature and wash away all abraded metal particles to prevent scratching.

Lapping

Lapping is an abrasive surface finishing process wherein fine abrasive particles are charged (caused to become embedded) into a soft material, called a lap. The material of the lap may range from cloth to cast iron or copper, but it is always softer than the material to be finished, being only a holder for the hard abrasive particles. Lapping is applied to both metals and nonmetals.

As the charged lap is rubbed against a surface, the abrasive particles in the surface of the lap remove small amounts of material from the surface to be machined. Thus the abrasive does the cutting, and the soft lap is not worn away because the abrasive particles become embedded in its surface instead of moving across it. This action always occurs when two materials rub together in the presence of a fine abrasive: the softer one forms a lap, and the harder one is abraded away.

In lapping, the abrasive is usually carried between the lap and the work surface in some sort of a vehicle, such as a grease, oil, or water. The abrasive particles range from 120 grit up to the finest powder sizes. As a result, only very small amounts of metal are

removed, usually considerably less than 0.025 mm. Because it is such a slow metal-removing process, lapping is used only to remove scratch marks left by grinding or honing, or to obtain very flat or smooth surfaces, such as are required on gage blocks or for liquid-tight seals where high pressures are involved.

Materials of almost any hardness can be lapped. However, it is difficult to lap soft materials because the abrasive tends to become embedded. The most common lap material is fine grained cast iron. Copper is used quite often and is the common material for lapping diamonds. For lapping hardened metals for metallographic examination, cloth laps are used.

Lapping can be done either by hand or by special machines. In hand lapping, the lap is flat, similar to a surface plate. Grooves usually are cut across the surface of a lap to collect the excess abrasive and chips. The work is moved across the surface of the lap, using an irregular, rotary motion, and is turned frequently to obtain a uniform action.

In lapping machines for obtaining flat surfaces, workpieces are placed loosely in holders and are held against the rotating lap by means of floating heads. The holders, rotating slowly, move the workpieces in an irregular path. When two parallel surfaces are to be produced, two laps may be employed, one rotating below and the other above the workpieces.

Various types of lapping machines are available for lapping round surfaces. A special type of centerless lapping machine is used for lapping small cylindrical parts, such as piston pins and ball-bearing races.

Because the demand for surfaces having only a few micrometers of roughness on hardened materials has become quite common, the use of lapping has increased greatly. However, it is a very slow method of removing metal, obviously costly compared with other methods, and should not be specified unless such a surface is absolutely necessary.